1.12.14. EVALUATION OF TECHNICAL STATE PARAMETERS OF ELECTRIC GRID AND POWER EQUIPMENT

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Algorithms are proposed to evaluate parameters of the technical state of electric grid and power equipment by informational and measuring systems (IMS) of “Zond” (electromagnetic method) and “Zond-IGT” (electric potential method) types, as well as by robotic systems of “Krot” (electromagnetic method) type. Results of practical application of evaluation of parameters of the technical state of electric grid and power equipment have confirmed the high efficiency of proposed algorithms.

Surface cracks are among defects, which are found most frequently in electric grid and power equipment. They occur during long-time operation of equipment, as well as in the event of violation of production technology or low-quality metal of equipment.

For evaluation of parameters of surface cracks IMS systems “Zond” and “Krot” were developed. In this case, the complexity of problem consists in processing and interpretation of measurement results, because errors in both set up and measurement of signals occur at IMS input and output.

At the same time, important practical problem was resolved when dispersions in errors during setting up of input modes and measurements at IMS output are unknown.

Such a problem occurs, for example, when depth of surface cracks on the edges of turbine blades is measured by means of systems like “Zond”. In the result of violations of technology of special plates brazing to the edges of turbine blades, zones of increased hardness occur, which leads to variation of conductivity. Herewith, signal at the IMS input varies, while errors in setting up of input modes differ noticeably from normal ones, i.e. they have somewhat abnormal character.

Similar problem also occur often during measurement of depth of surface cracks in enclosures of electric grid equipment by means of systems of “Zond-IGT” type, as well as during evaluation of cracks depth in the rotor axial duct by means of systems of “Krot” type. In this case, displacement of the probe center in respect of crack plane affects IMS input signals, which results in occurrence of errors in input signals having abnormal character. Moreover, dispersions of main distributions are unknown in both cases.

Active mode is considered, when input signals x_{0i} are given with additive errors h_i, while output ones y_i are measured with some errors ξ_i:

$$\begin{cases} y_i = \theta x_i + \xi_i, \\ x_i = x_{0i} + h_i, \end{cases} \tag{1}$$

where θ – is unknown parameter (surface crack depth); x_i – are signals directly coming to IMS input; $i = 1, \ldots, n$ – are point, where measurement is performed

$$h_i \in (1-\varepsilon_h) N(0, \sigma_h^2) + \varepsilon_h \Phi(h), \tag{2}$$

$$\xi_i \in (1-\varepsilon_\xi) N(0, \sigma_\xi^2) + \varepsilon_h \Phi(\xi), \tag{3}$$

where N – is the main normal distribution; Φ – are some symmetrical distributions; σ_h^2 and σ_ξ^2 – are unknown dispersions of main distributions of errors in IMS input and output signals; ε – is probability of appearance of abnormal errors.

Iteration procedure is proposed for plotting of stable estimations $\hat{\theta}$ of parameter θ, which posses with good statistical properties.

Passive mode is considered, when factors affecting IMS vary under impact of unknown reasons. In this case, input signals are measured with some additive errors h_i, while output signals y_i are measured with additive errors ξ_i, i.e. IMS can be presented in the following form

$$\begin{cases} y_i = \theta x_{0i} + \xi, \\ x_i = x_{0i} + h_i, \end{cases} \tag{4}$$

where, in respect of errors h_i and ξ_i, the same information is valid as for the case of active mode.

Evaluation of unknown parameters θ and σ_h^2 from expression (4) is very complex task due to abnormal character of distribution of errors h_i and ξ_i.

If input signals x_{0i} admit parametrization of the following form

$$x_{0i} = \psi(\bar{\gamma}, t_i), \tag{5}$$

where ψ – is unknown function; t – is some dummy variable; $\bar{\gamma}$ – is a vector of unknown parameters, expression (4) can be presented in the following form

$$\begin{cases} y_i = \theta\psi(\bar{\gamma}, t_i) + \xi_i, \\ x_i = \psi(\bar{\gamma}, t_i) + h_i. \end{cases} \tag{6}$$

Estimations $\hat{\theta}$, $\hat{\sigma}_h^2$ of unknown parameters θ, σ_h^2 from expression (6) are found by the similar iteration method as in the case of active mode. Estimations θ_m, σ_m^2 obtained by iteration method posses with good statistical properties.